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ABSTRACT

Four hundred students, ranging from 5 to 15 years of age, were administered a series of tests of concept learning and development as a test of the Conceptual Learning and Development (CLD) model. Various levels of attainment of the concept of "equilateral triangle" were measured. The CLD model predicts that a decreasing number of students at a particular age will pass successively higher levels of concept attainment while the number and proportion of students passing each level will increase with increased age. Results reflect these predictions. It was also found that there was an invariant sequence of mastery of each of the four concept levels, and that students who can label the concepts will show superior concept attainment. (SBT)

A Model of Conceptual Learning and Development:

Empirical Validation of the Concept Attainment Levels[1, 2]

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The present paper is concerned with the assessment of those predictions of the CLD model which pertain to attainment of the concrete, identity, classificatory, and formal levels. To reiterate briefly the predictions presented in an earlier paper, there are three types of predictions which stem directly from the CLD model: those dealing with age or grade, those concerning the invariant sequence of concept level attainment, and those involving language or vocabulary. One major purpose of the study to be described was to test these predictions.

Four hundred students, ranging from 5 to 15 years of age, were sampled from Beloit, Wisconsin, public schools. One hundred students (fifty females and fifty males) from kindergarten, third, sixth, and ninth grades were administered an assessment battery dealing with the concept equilateral triangle (Klausmeier, Ingison, Sipple, & Katzenmeyer, 1973). The equilateral triangle battery was one of several curriculum-based concepts serving as target concepts in testing the predictions of the CLD model.

Equilateral triangle, and other target concepts met the following criteria. Each concept had to be related to some broad subject matter area such as mathematics, English language arts, or science. Further, target concepts had to have publicly definable, perceptible attributes. Finally, the chosen concepts were required to occupy a specifiable position in a taxonomy

of related concepts, in order to assess knowledge of superordinate-subordinate relations.

Construction of the assessment battery for equilateral triangle proceeded in the following manner. Subtests were constructed, one for each of the four levels of concept attainment (as well as the three uses). Items in each subtest were specifically written to assess only those operations postulated to be operating at a specific level. In addition, each subtest contained a number of individual items which varied in difficulty according to the number and type of concept examples and nonexamples presented. Figure 1 illustrates items drawn from the four subtests dealing with the levels of attainment of the concept, equilateral triangle.

As can be seen in Figure 1, the students' task for the concrete and identity items involved the selection of a previously seen example figure from among some number of nonexamples. In concrete items, the example figure was always presented in exactly the same orientation among the non-examples as when originally seen. For identity items, the example figure was never presented in the same orientation. Items within concrete and identity varied in difficulty according to the number and type of non-examples shown. For the classificatory items, the student's task was to choose all those figures which shared certain attributes (e.g., shape, color, size, or a combination of these attributes) with the target figure. Finally formal level items required knowledge of defining attributes as well as labels for the concept and attributes.

Each subtest was administered to intact classroom groups, except at the kindergarten level, by two experimenters. At the kindergarten level, the subtests were administered to groups of ten children. The entire task battery

took approximately one hour to administer. Feedback was not provided to the students. Performance of all students on each subtest was evaluated in terms of success (pass) or failure to show complete attainment of the concept at each level.

It will be recalled that the CLD model specifically predicts that the number and proportion of students at a particular age who pass each successively higher level of concept attainment will decrease, while the number and proportion of students passing each level will increase with increased age. Table 1 presents data relevant to these predictions.

Inspection of Table 1 reveals that the predictions of the model are borne out. Each grade shows, in general, successive decreases in the proportion passing each higher level, from concrete through formal. Further, performance at each concept level improves with increasing age. Significant differences between grades were found at each concept level [x^2_3=38.30 (concrete), =38.57 (identity), =103.67 (classificatory), and =168.62 (formal, $p<.001$]. A Chi square analog to Scheffe's theorem was performed at each level, revealing significant grade differences only between kindergarten and all other grades at the concrete and identity levels ($p<.05$). At the classificatory level, kindergarten students were again significantly different from all other grades ($p<.05$). In addition, third grade students performed more poorly than students in the 9th grade ($p<.05$). Finally, at the formal level, all grades were significantly different from each other ($p<.05$ for all comparisons). Such data offers strong support for the age or grade-related predictions of the model.

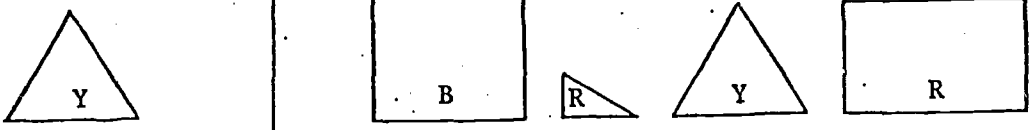
A second prediction of the CLD model involves the invariant sequence of mastery of each of the four concept levels. According to the CLD model,

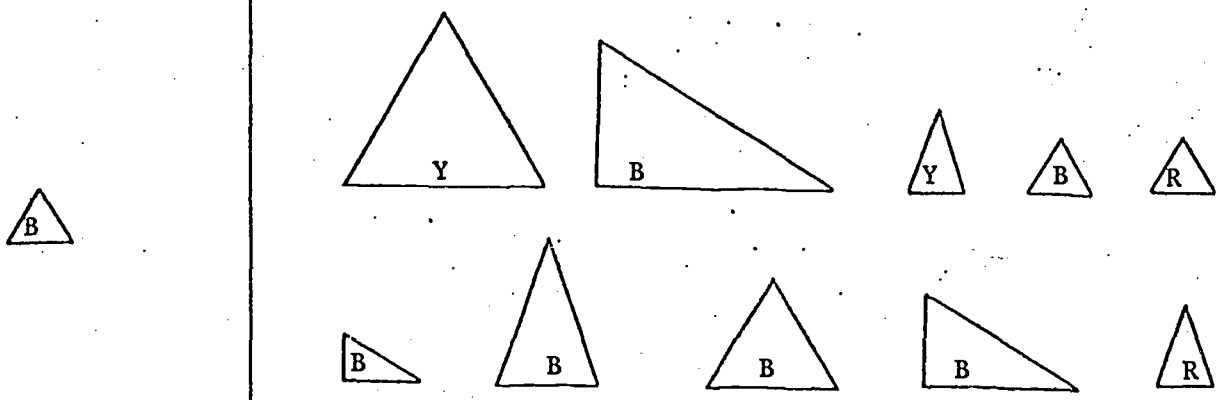
attainment of the concept at any higher level requires attainment of all lower levels. Thus, there are a total of five sequences of passing or failing the four levels that conform to the model, and a total of eleven such sequences which do not. Table 2 presents the number and proportion of students at each grade level conforming to the five acceptable and eleven unacceptable patterns of attainment. Specifically, inspection of Table 2 reveals that the overwhelming majority of students conform to the five acceptable patterns of attainment. Eighty percent of the kindergarten children conformed to one of the five acceptable patterns. Further, successively higher proportions of children conform to these patterns with increased age. Thus, we see that 86% of the third graders and 95% of the sixth graders show one of the five patterns; and by the 9th grade, 99% of the children conform to the predictions of the model.

Finally, the CLD model predicts that those students having labels for the concept as well as for the concept attributes will be more likely to show concept attainment than those students lacking such vocabulary. In order to test this prediction, the performance of the students who demonstrated knowledge of the vocabulary relevant to equilateral triangle was compared to the performance of those students lacking this vocabulary. Significant differences were found between these vocabulary groups at each of the four concept levels [χ^2_1=15.82 (concrete), =14.63 (identity), =37.92 (classificatory), and =61.39 (formal), $p<.001$]. Phi coefficients performed at each level revealed a relatively low correlation between vocabulary proficiency and attainment of any level [ϕ=.19 (concrete), =.19 (identity), =.31 (classificatory), and =.39 (formal)]. However, it can be seen that the correlation between these variables increases from the early levels of attainment through later levels, in a direction predicted by the model.

To briefly summarize, this paper has presented evidence related to three types of predictions stemming from the CLD model. Data from the present study offer strong support for predictions pertaining to grade differences as well as the predicted order of concept level mastery. Knowledge of relevant vocabulary, however, appears to be only moderately correlated with concept level attainment. The following paper will present data relevant to the three concept uses.

Concrete level example items





Identity level example items

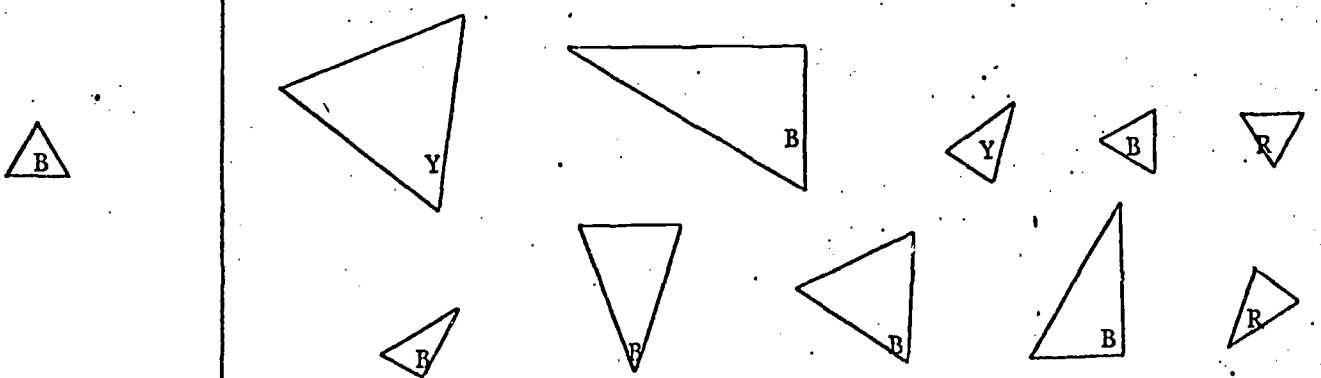
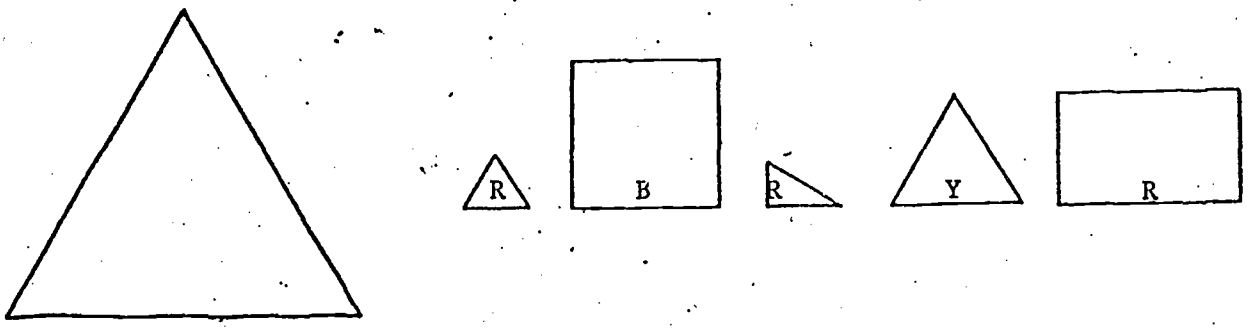


Figure 1. Example Items

Put an X on the drawings on the right that have exactly the same shape as the one on the left.



Put an X on the drawings on the right that have exactly the same shape and the same size as the one on the left.

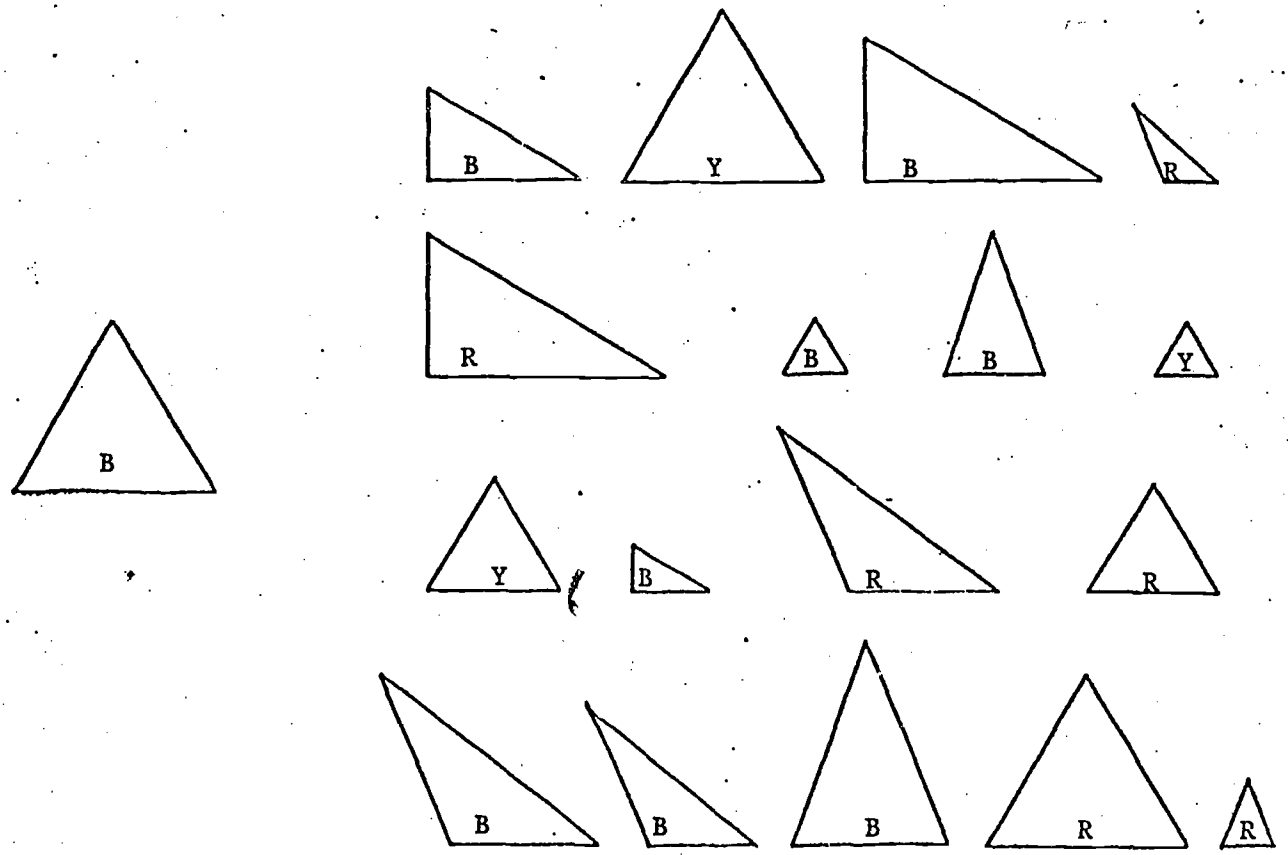
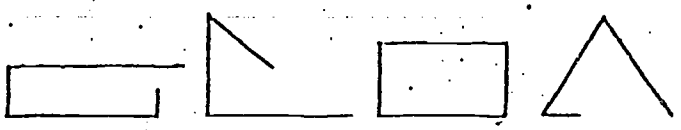
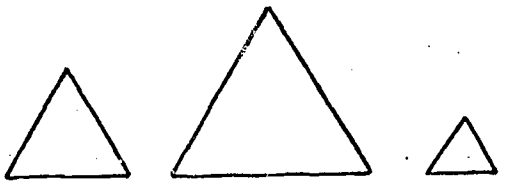


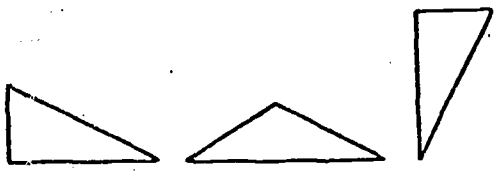
Figure 1 cont.

Below are four drawings. Put an X on the one that is different from the other three.





Group 1



Group 2

Which one name best fits all of the drawings in Group 1 but does not fit all of the drawings in Group 2?

a. scalene triangles

b. right triangles

c. obtuse triangles

d. equilateral triangles

e. I don't know.

Key: R - red
B - blue
Y - yellow

Figure 1 cont.